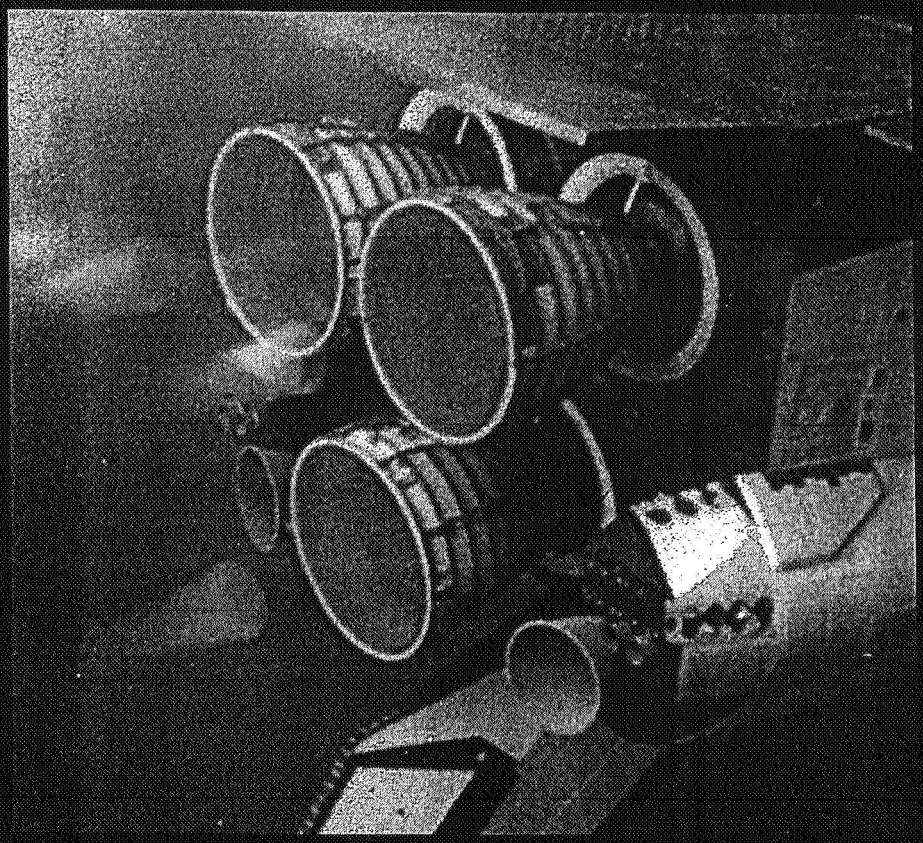


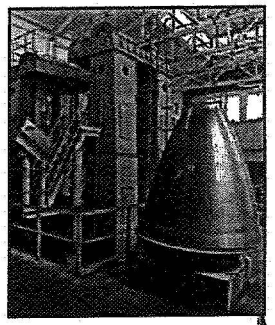
Channel-Wall Nozzle Program
Agenda

- **Background and benefits of a Channel-Wall Nozzle**
- **Phase I Status**
- **Phase II Plan**
- **Summary**

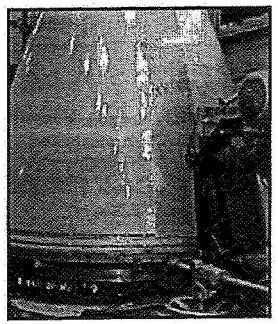
SSME Nozzle Upgrade
Background

- **Top NASA-MSFC SSME upgrade priority**
- **Level II Upgrade Board approved $0.8M for Phase I Technology Program for SSME channel-wall nozzle program in Dec. 1997**
- **Engine 0524 Incident Investigation Board recommends aggressively pursuing channel-wall technology**
- **Technology is applicable to SSME, LFBB and other reusable vehicle programs**

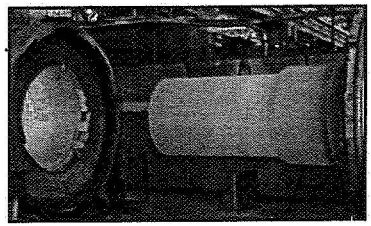
Channel-Wall Nozzle
Robust Manufacturing Processes



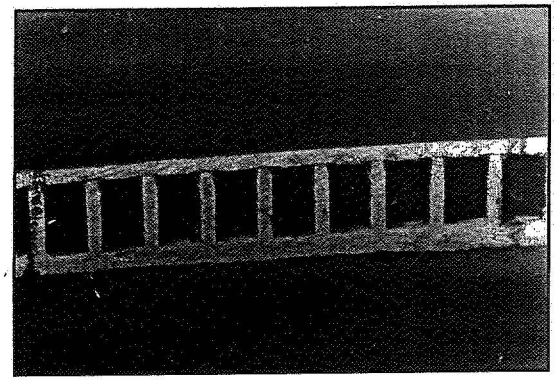
Forming



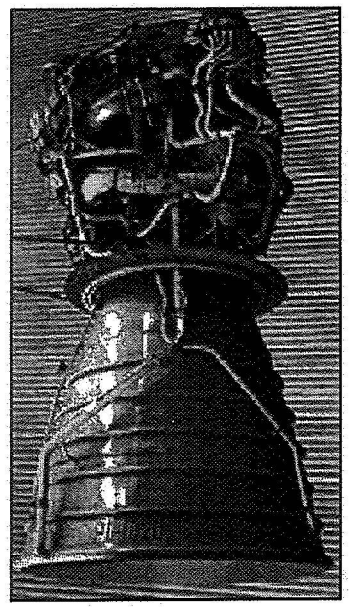
Slotting



Brazing



Welding



Channel-Wall Nozzle
Benefits to Shuttle Program

- Improved safety and reliability
  - Simplified design -- fewer parts and welds
  - Reduced likelihood of crit 1 & 1R failures
- Increased performance
  - 1.0-1.5 Isp gain from smooth inner wall and optimum contour for use with LTMCC
- Engine simplification
  - Design goal to eliminate need for Chamber Coolant Valve (CCV)

Channel-Wall Nozzle
Benefits to Shuttle Program (cont'd.)

- Reduced unit cost
  - Production cost estimated at half current nozzle
- Reduced cycle time
  - Fabrication process time of 18 months versus current 32 months
- Low operations cost
  - History of the channel-wall nozzle reports no leaks or repairs
  - Improved seal between MCC and Nozzle (Eliminates Flow Recirculation Inhibitor Replacement)
  - Improved TPS attachment

Channel-Wall Nozzle
Benefits to Other Programs

- Risks reduced with Phase II validations
  - Life and reliability of basic design features
  - Manufacturing cycle time
  - Production costs
  - Ability of CADB/VMP to work to NASA & ISO 9001 requirements and deliver on-schedule
- Cost savings to other programs
  - Validation of design methodology
  - Materials characterization
  - Special equipment start-up costs

Channel-Wall Nozzle
Phase I Program Status

- Preliminary Design Review held Mar. 16-19 in Voronezh
- Technical Reviews at NASA-MSFC in April and May
  - CADB and VMP participated in May review
- Action items generated and are being worked
- Rocketdyne conducting independent analyses of critical areas to validate Russian results
- Critical Design Review scheduled for August 1998

Channel Wall Nozzle for SSME
Design Status

- Understanding Russian analysis methodology
  - Fatigue, fracture, materials
- Life critical areas are being re-analyzed using Rocketdyne methodology for comparison
- Engine start transient conditions being verified
- Weight is within expected range < 1400 lbs without TPS
- Current tube nozzle weight is approximately 1300#
- Material properties established by CADB -- additional U.S. validations to be completed in Phase II
- Reliability of new design features being assessed

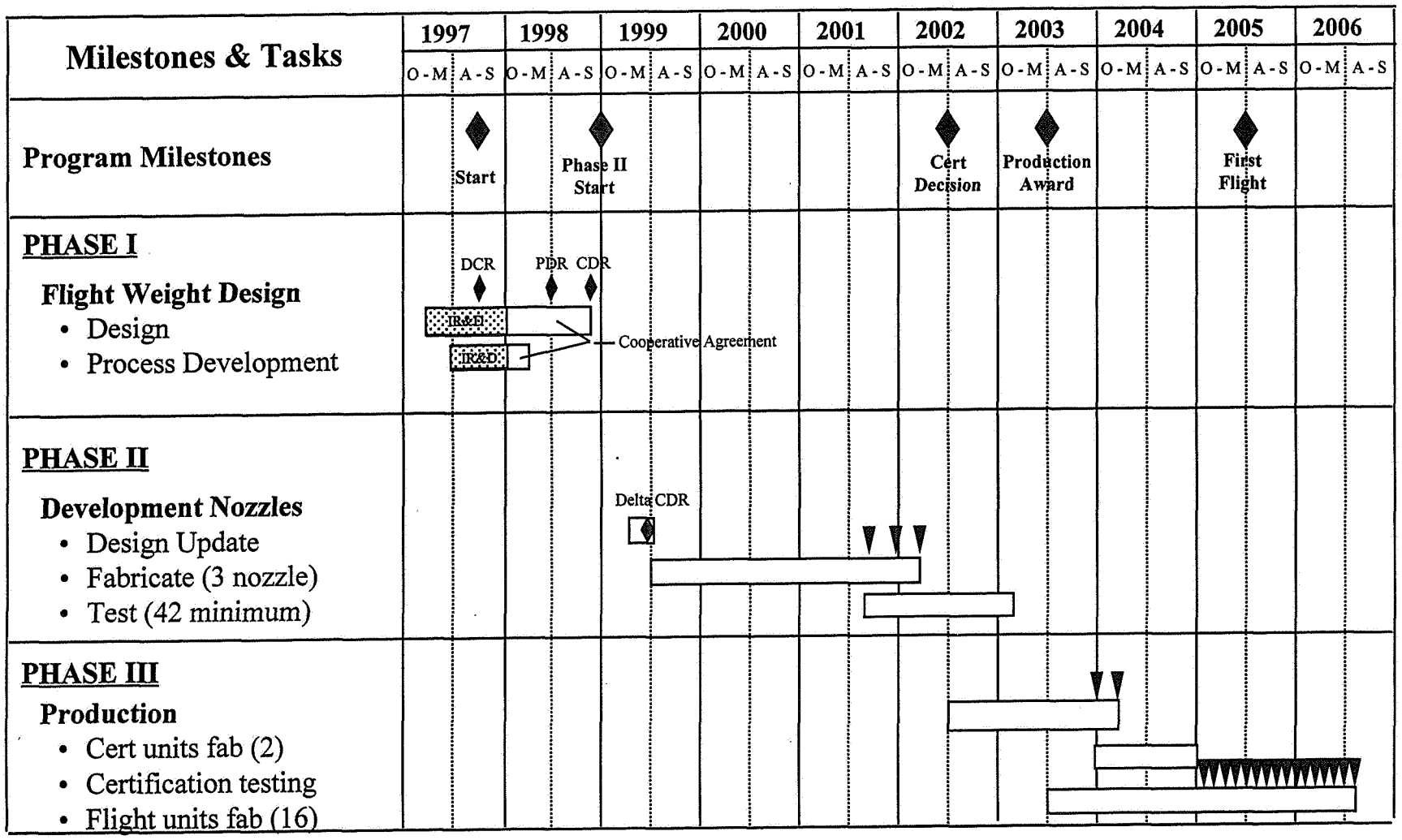
Channel-Wall Nozzle

Phase II Development Plan

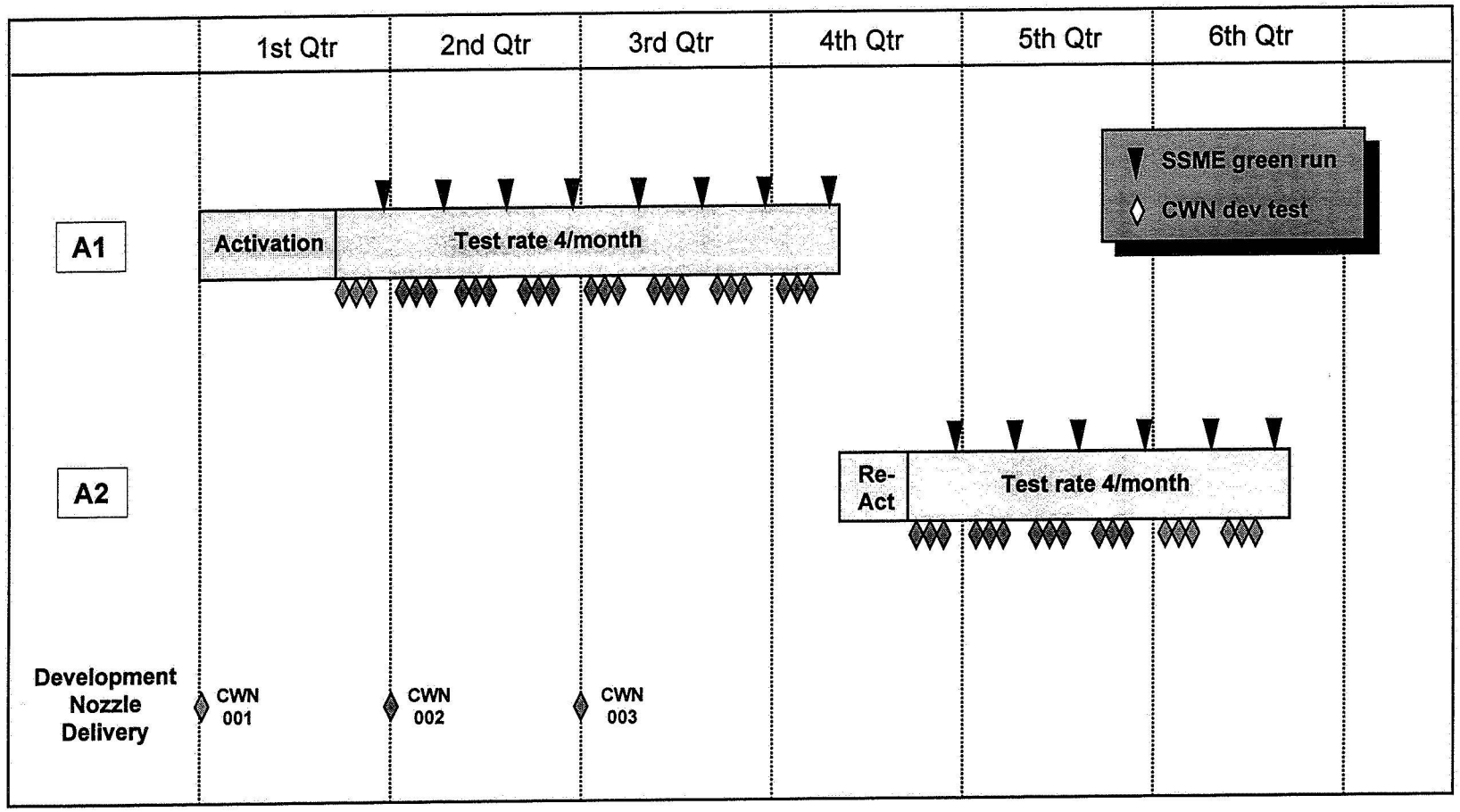
Channel-Wall Nozzle
Phase II Plan

- Conduct carry-over design validations
- Build 3 development nozzles
- Demonstrate capability with 42 hot-fire tests
  - Use one test stand
  - Fit between component green run testing
  - Dedicate one development engine for CWN testing
  - Begin testing on A1 (sea level stand) for preview of durability
  - Migrate testing to A2 (altitude stand) for performance verification

Channel-Wall Nozzle
Project Schedule



Channel Wall Nozzle Test Schedule
Phase II Development



Channel-Wall Nozzle Program
Phase II Timeline

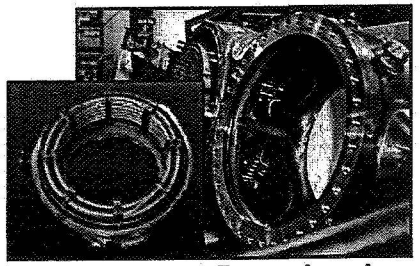
- **GFY 1999** **$10.0M**
  - Complete carry-over design tasks
  - Order nozzle and tooling material
  - Complete tooling designs and tooling fabrication
- **GFY 2000** **$14.0M**
  - Initiate nozzle component fabrication
- **GFY 2001** **$19.5M**
  - Complete fabrication of 3 nozzles
  - Begin development testing
- **GFY 2002** **$19.6M**
  - Complete development testing

Channel-Wall Nozzle
Phase II Summary

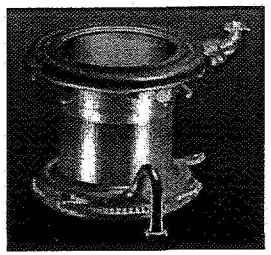
- Provides thorough assessment of channel-wall technology
  - Demonstrates reusability of channel-wall construction
  - Validates production cycle and cost
  - Evaluates repeatability of processes
- Cost effective -- minimizes need of Upgrades budget
- Meets schedule needs

Space Shuttle Program Development Office

Space Shuttle Main Engine Upgrades



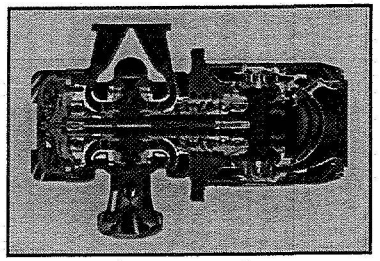
Two-Duct Powerhead
Single Coil Heat Exchanger
Main Injector Isp Mods



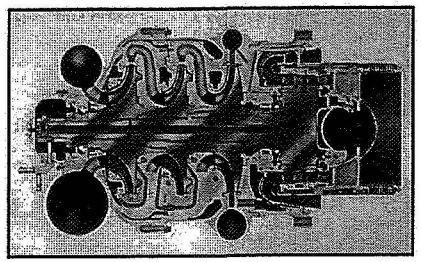
Large Throat Main
Combustion
Chamber

Block I & II
Upgrades

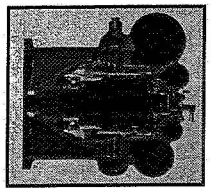
Upgrades
(Under Consideration)



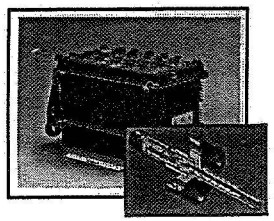
Alternate High
Pressure
Oxidizer Turbopump



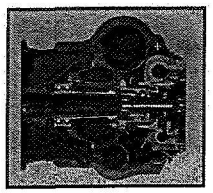
Alternate High
Pressure Fuel
Turbopump



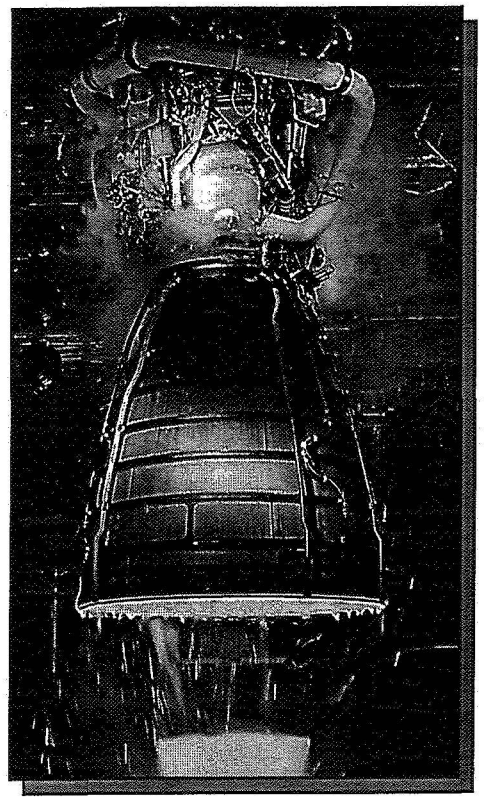
Low Pressure
Oxidizer Turbopump

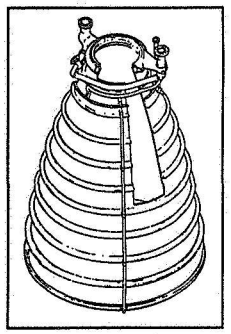


Software &
Sensors

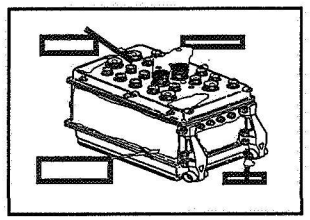


Low Pressure Fuel
Turbopump

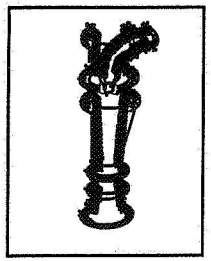




Channel Wall Nozzle



Advanced Health
Management System



Oxidizer Jet Pump

Channel-Wall Nozzle
Summary

- **Benefits of channel-wall nozzle merit continuation of phased program**
- **Potential for increased safety, reliability and performance at a lower life cycle cost**
- **Technology applicable to future propulsion systems**

Request $10M in 1999 and total of $63.1M over 4 years for Phase II

Defense and Civil Space Programs Conference and Exhibit

Von Braun Center
Huntsville, Alabama
October 28–30, 1998

General Cochairs
Carolyn S. Griner, NASA Marshall Space Flight Center
LTG Edward G. Anderson, U.S. Army Space and Missile Defense Command
MG Emmitt E. Gibson, U.S. Army Aviation and Missile Command
MG Richard (Dick) Paul, Executive Director, Air Force Research Laboratory, Air Force Materiel Command

Executive Chair:
Larry D. Knauer, Lockheed Martin

Executive Technical Chair
Keith J. Frederick, Lockheed Martin

Technical Program Chair
Joyce K. Neighbors, Lockheed Martin

Session Planners

Frank Swalley, NASA Marshall Space Flight Center
David Hayes, U.S. Army Space and Missile Defense Command
William C. Pittman, U.S. Army Aviation and Missile Command
CDR Austin Boyd, U.S. Naval Space Command
Mike Jacox, Phillips Laboratory, U.S. Air Force
Charles Eldred, NASA Langley Research Center
Steven Pavelitz, Sverdrup Technology, Inc.
Evan Eller, Allied Signal
Ellen Hoff, W.L. Pritchard & Co., Inc.
Robert Jackson, NASA Marshall Space Flight Center
Eric Shaw, NASA Marshall Space Flight Center
Mary Harris, NASA Marshall Space Flight Center
William W. Vaughn, University of Alabama, Huntsville

Synopsis

The 1998 Defense and Civil Space Programs Conference presents a unique forum dedicated to the latest developments in space programs and to the use of space assets for defense, civil, and commercial applications. Leading policy makers for these assets will focus on collaboration between government and industry to maximize affordability of space programs and technology.

The conference will focus on status and plans of Army, Navy, Air Force, NASA, and commercial programs, assets, and technologies for multiple defense, civil space flight, and commercial users. Major areas of interest include space transportation, space systems, space operations & support, economics, and avionics. This conference presents valuable insights from senior aerospace officials into national space programs and technologies of major government and industry customers and providers.

Registration

All participants are urged to use the advance registration form found on page B15. Registering in advance saves conference attendees $50. A check made payable to AIAA or credit card information must be included with your registration form. Early Bird registration forms must be received by September 30, 1998. Preregistrants may pick up their materials at the advance registration desk. All those not registered by September 30, 1998, may do so at the onsite registration desk. If you require more information, please call 800/NEW-AIAA or 703/264-7500.

Registration fees are as follows:

	By 9/30/98	After 9/30/98
*Full Conference		
Member	$360	$410
Nonmember	$485	$535
**Full-Time Student		
Member	$0	$10
Nonmember	$25	$35
**Full-Time Retired		
Member	$0	$10
‡Block		
Member	$225	N/A
Nonmember	$225	N/A
§One Day	$225	$225

*Includes conference and exhibits participation, lunch each day, Wednesday and Friday evening receptions, and a bound collection of conference papers.

**Includes conference and exhibit admission only.

‡Advance only. One complete typed list of ten or more from the same organization. Includes conference and exhibit admission only.

§Includes one day of conference and exhibit admission only. Date must be specified.

NASA Marshall Employees Attend Free

Badged employees of NASA Marshall Space Flight Center will be admitted free of charge because of previous registration arrangements with AIAA. Sign in at the onsite registration desk to receive a conference badge and admission. (Conference participation and exhibits only. Food functions not included.)

Register on our Web Site

Those wishing to attend this conference who plan to pay by credit card may use the online conference registration form (hosted on a Netscape Secure Commerce Server) for this conference, available at http://www.aiaa.org/ calendar/space98reg.html. You can also download Adobe Acrobat versions of the conference registration form, which you can print, fill out, then mail or fax with payment to AIAA. Calls for papers and programs for all of AIAA's conferences can be accessed from http://www.aiaa.org/calendar/index.html.

Registration hours are as follows:

Tuesday, October 27	4:00 pm–7:00 pm
Wednesday, October 28	7:00 am–4:00 pm
Thursday, October 29	7:00 am–4:00 pm
Friday, October 30	7:00 am–2:30 pm

Hotel Reservations

AIAA has made arrangements for a block of rooms at the Huntsville Hilton, 401 Williams Avenue, Huntsville, AL 35801. For reservations call 205/533-1400. Room rates are $78 for singles and $88 for doubles. Please specify in advance the time and date of arrival and departure and identify yourself as an AIAA meeting participant. These rooms will be held for AIAA until September 15, 1998, and then released for use by the general public. Most hotels will not honor late arrivals unless it is specified in advance that you or your company agrees to pay for your room if you fail to show. After 6:00 pm, a room not guaranteed is considered a "no show" and will be offered to the next available customer. Government Employees—a limited number of sleeping rooms is available at the government hotel per diem; ID is required.

Getting There for Less

Call Conventions in America, the official travel agency of AIAA, at 800/929-4242, ask for Group #578. You will receive 5–10% off the lowest applicable fares on Delta Air Lines or the lowest available fare on any carrier. Take an additional 5% off Delta if you purchase at least 60 days prior to departure. Travel window: October 25–November 2, 1998. All attendees booking through Conventions in America will receive free flight insurance of $100,000. If you call TWA directly at 800/325-4933, ask for File #117508A.

Avis Rent A Car is offering special low rates with unlimited free mileage. Call 800/331-1600 and refer to AWD #A273699.

Transportation

The Huntsville Hilton is located approximately 13 miles from the airport. Courtesy transportation from the airport to the hotel is available.

Interagency Collaborations for Earth and Space Science Technologies (Effective R&D partnering)

Session Chair: Dr. Peter B. Ulrich, director of the Advanced Technology and Mission Studies Division, NASA Office of Space Science.

Papers are solicited that describe the results of a collaborative effort in technology development between two or more government (federal, state, local, or international) funding agencies each with an independently appropriated budget (at least one must be an agency or department of the United States of America). Authors funded by such agencies may be employed by industries, universities, government, or may be private individuals. The collaboration must be substantive during the technology development, essential to achieve the results reported, and not limited to the joint writing of the paper submitted.

Only collaborative work (as described above) will be accepted; any technology that furthers the Earth and Space Science programs of NASA is welcome. The session will be held in two or three venues, each consisting of no more than five papers. A maximum of 15 papers—selected according to technical quality—will be accepted for the session.

Deadlines & Procedures

Abstracts are due to the conference technical chair by **August 14, 1998.**

Dr. Joyce Neighbors
Lockheed Martin Michoud Space Systems
620 Discovery Drive, Bldg. 2, Suite 200
Huntsville, AL 35806
205/922-3329 • 205/922-3366 FAX
e-mail: joyce.neighbors@ast.lmco.com

Selected authors will be notified by **August 28, 1998.**

Full papers and written statement describing utilization of cash award due **October 8, 1998** to:

Susan Busby
Technical Papers Manager
AIAA
1801 Alexander Bell Drive, Suite 500
Reston, VA 22091
703/264-7564 • 703/264-7551 FAX
e-mail: susanb@aiaa.org

NASA Effective Partnerships Prize

The best paper will receive the NASA Effective Partnerships Prize and a cash award of $10,000. The selecting official is the Director of the Advanced Technology and Mission Study Division in the NASA Office of Space Science. A recommendation will be forwarded to the selecting official by the Review Panel. The Review Panel represents a balance of practicing technologists and technology managers from NASA and other agencies of the U.S. Government.

The Review Panel will use the following criteria (equally weighted) for evaluating the papers:

- Technical excellence of the contribution;
- Short- and long-term benefits for Earth and Space Science at NASA;
- Degree of synergism among the programs in the collaboration; and
- Proposed utilization of the cash award (any legal use qualifies and is acceptable, however the Review Panel will value more highly original approaches aimed at furthering: 1) effective partnering among agencies, 2) education, or 3) public outreach).

The award will be presented to the author(s) during a formal ceremony at the AIAA Defense & Civil Space Conference, Huntsville, Alabama, October 30, 1998.

To be considered for the Effective Partnerships Prize and cash award a written paper must be submitted by **October 8, 1998.** Every paper accepted in the session will be entered in the competition for the Effective Partnerships Prize and cash award, provided it is accompanied by a written statement by the author(s) describing the proposed utilization of the cash award.

Note: No prize or award may be given if, in the judgement of the selecting official, an insufficient number of papers are accepted for the session.

Exhibits

The exhibition features high-technology exhibits from major aerospace and subsystem companies. All conference attendees and industry-related personnel may view the exhibition FREE. Exhibit hours will be:

Wednesday, October 28	11:30 am–4:00 pm 5:00 pm–6:30 pm (Reception)
Thursday, October 29	11:30 am–5:30 pm
Friday, October 30	11:30 am–2:00 pm 5:30 pm–7:00 pm (Reception)

Join AIAA exhibitors for a reception on Wednesday and Friday evenings and for coffee breaks in the exhibit hall.

For more information on exhibiting, contact Howard O'Brien, Jr. at 800/739-4424.

Special Events

Daily Luncheon

Luncheon is included in the registration fee where indicated. Additional tickets may be purchased for $20 at the AIAA onsite registration desk or with the advance registration form found on page B15. Please note that an Awards Luncheon will be held on Friday, October 30.

Wednesday Luncheon Speaker

LTG Lance W. Lord, vice commander of the Air Force Space Command

Thursday Luncheon Speaker

Ron Taylor, vice president and general manager, Iridium

Friday Luncheon Speaker

Dr. George Mueller, chief executive officer, Kistler Aerospace

1st Annual Von Braun Dinner Golf Outing

Saturday, October 31, 1998, 0800 (8:00 a.m.) Hampton Cove Golf Course, a Robert Trent Jones Design, Huntsville, Alabama.

Format: 4 person modified scramble

The golf outing will be followed immediately with a cookout on the veranda of the Hampton Cove Club House. Team and individual prizes will be awarded.

For additional information please contact Steve Humphrey, Lockheed Martin,1500 Perimeter Parkway, Suite 123, Huntsville, AL 35806; 256/830-9200, fax: 256/830-8338, e-mail: steven.humphrey@lmco.com

Receptions

Wednesday, October 28

A Wednesday evening reception in the Exhibit Hall is included in the registration fee where indicated. Additional tickets may be purchased for $20 each at the AIAA onsite registration desk or with the advance registration form found on page B15.

Friday, October 30

Von Braun Memorial Celebration

Founded in 1988, this dinner honors the memory of Dr. Wernher von Braun by recognizing those individuals and groups who have made great achievements in advancing space flight programs and who have contributed to U.S. leadership in the fields of rocketry and astronautics. Hosted by The National Space Club and NASA Marshall Space Flight Center, the Von Braun Memorial Celebration will be a combined event (Von Braun Memorial Reception and Dinner/Awards and Exploration Forum) for the first time. The dinner will be held at the Von Braun Center in the North Hall on Friday, October 30, at 7:00 pm with a pre-dinner reception in the Exhibit Hall at 5:30 pm. Tables of eight or individual seats are available for sale at a cost of $800 and $100, respectively. For more information on the Von Braun Memorial Celebration, please call the Event Organizers at 256/890-6811.

Bound Collection of Papers

A bound collection of papers is included in the registration fee where indicated. Additional volumes may be purchased as follows:

During the meeting		$35.00
After meeting sales	Member	$52.50
	List Price	$75.00

To order this collection of papers after the meeting please write, phone, or fax: American Institute of Aeronautics and Astronautics, Publications Customer Service, 9 Jay Gould Court, P.O. Box 753, Waldorf, MD 20604. Phone: 800/682-2422; FAX: 301/843-0159.

Presentations without paper numbers are oral presentations only and will not be available in print for sale by AIAA.

Journal Publication

Authors of appropriate papers are encouraged to submit copies of their preprints for possible publication in one of the Institute's archival journals: *AIAA Journal*; *Journal of Aircraft*; *Journal of Guidance, Control, and Dynamics*; *Journal of Spacecraft and Rockets*; *Journal of Propulsion and Power*; or *Journal of Thermophysics and Heat Transfer*. See the inside front cover of the journal of your choice for the name and address of the editor-in-chief.

Speakers' Briefing

Authors who are presenting papers and session chairs will meet in North Hall 2 for a short briefing each morning at 7:00 am. Breakfast will be provided.

Speakers' Practice

Speakers wishing to practice their presentations may use the Board Room for 30-minute increments. There will be a sign-up sheet posted on the door. Speakers may indicate on this sheet when they will be using this room.

Timing of Presentations

Each paper will be allotted 30 minutes (including introduction and question-and-answer period) except where noted.

Audiovisual

Each session room will be preset with the following: one overhead projector, one screen, and one microphone. A 35-mm slide projector, 1/2-inch VHS VCR, and a monitor will be set only in the rooms where the session chair has requested them. If you require additional AV equipment, please contact Joanne Hauser at 703/264-7563 no later than Wednesday, October 7. After October 7, any additional audiovisual requirements will be at the cost of the user.

Messages and Information

Messages will be recorded and posted on a bulletin board in the registration area. It is not possible to page attendees. Please call 205/551-2350 and ask for the AIAA meeting.

Employment Opportunities

AIAA is assisting members who are searching for employment by providing a bulletin board at the technical meetings. This bulletin board is solely for "open position" and "available for employment" postings. Employers are encouraged to have personnel who are attending an AIAA technical conference bring "open position" job postings. Individual unemployed members may post "available for employment" notices. AIAA cannot assume responsibility for notices forwarded to AIAA headquarters. AIAA reserves the right to remove inappropriate notices.

AIAA also now provides to its members Career Planning and Placement Services on its web site, located at http://www.sheridan.com/aiaa/employment/index.html. Members can post and browse resumes, browse job listings, and access other online employment resources.

Membership

Nonmembers who qualify for AIAA membership and who pay the full nonmember fee will receive their first year's membership at no additional cost when their membership application is completed and returned with the registration form to AIAA. Students who are not members may apply their registration fee toward their first year's student member dues.

Nondiscriminatory Practices

AIAA accepts registrations irrespective of race, creed, sex, color, physical handicap, and national or ethnic origin.

Smoking Policy

Out of courtesy to others, smoking is not permitted in the technical sessions.

Restrictions

Videotaping or audio recording of any session during this conference is prohibited. The sale of any publication not authorized by AIAA is also prohibited.

Department of Defense Approval

On reviewing the American Institute of Aeronautics and Astronautics' proposal, the Department of Defense finds this event meets the minimum regulatory standards for attendance by DoD employees. This finding does not constitute blanket approval or endorsement for attendance. Individual DoD component commands or organizations are responsible for approving attendance of its DoD employees based on mission requirements and DoD regulations.

Wednesday Afternoon / October 28, 1998

1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00

Session 1 Life Cycle System Engineering
Chaired by: T. MCVEY, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL, and S. EDWARDS, Edwards Industries, LLC, Ellicott City, MD

Challenges in Missile Life Cycle System Engineering T. Howard III, *Army Aviation & Missile Command*, Redstone Arsenal, AL	**Reengineering a Single Threaded Imbedded Missile Application onto a Parallel Processing Platform Using Meta H** B. Lewis, D. McConnell, and L. Gray, *Army Aviation and Missile Command*, Redstone Arsenal, AL	**AIAA-98-5101** **The Effects of DoD Acquisition Streamlining Initiatives on the Software Development Process: A Case Study** W. Shankle, *Army Aviation & Missile Command*, Huntsville, AL	**Remote Readiness Asset Prognostics/Diagnostics System (RRAPDS)** S. Marotta and T. Erickson, *Army Aviation & Missile Command*, Redstone Arsenal, AL	**Resolving the Impact of Diminishing Sources and Material Shortages to Production and to Fielded Systems** E. Biancante, *Comarco Systems, Inc.*, Bloomfield, IN; R. Easter, *Manufacturing Technology, Inc.*, Huntsville, AL	**The Product Developer in Transition: Making the Move from Traditional to Life-Cycle Based Economic Analysis** P. Componation, *Univ. of Alabama in Huntsville*, Huntsville, AL		

Session 2 Opportunities for Commercial Collaboration in Naval Space Technologies
A. BOYD, Naval Space Command, Dahlgren, VA

AIAA-98-5103 **A Menu of Joint, Flexible, Scaleable Space-Ground Architectures for Small Unit Operations** L. Mayoral, *Raytheon Systems Co.*, Falls Church, VA	**AIAA-98-5104** **Direct Sensor to Weapon Network Architecture** A. Brown, *NAVSYS Corp.*, Colorado Springs, CO	**AIAA-98-5105** **Unmanned Aerial Vehicles and Satellite Communication Systems** V. Wiggins, *Joint C4ISR Decision Support Center*, Arlington, VA	**AIAA-98-5106** **Spectrum Management Issues Concerning Military Use of Commercial Space** R. Cowen-Hirsch, *Joint Spectrum Center*, Annapolis, MD; S. Timmerman, *IIT Research Inst., Annapolis, MD*	**AIAA-98-5107** **Modeling of Satellite Communications Systems — An Increasing Need for High Fidelity Models** R. Wilson and H. Melton, *SPARTA, Inc.*, San Diego, CA	**AIAA-98-5108** **Challenges in Control for Line of Sight (LOS), Wideband SATCOM, and Narrowband DAMA SATCOM Avionics** K. Stenger and R. Bradley, *DCS Corp.*, Alexandria, VA	**AIAA-98-5109** **Spectrally Efficient High Data Rate Waveforms for the UFO SATCOM Channel** R. Middlestead, R. Battista, and R. Jacobson, *Linkabit*, San Diego, CA	

Session 3 Near Term/Evolutionary Systems: Part 1: Shuttle Upgrades
M. HENDERSON, NASA Johnson, Houston, TX and J. SMELSER, NASA Marshall, Huntsville, AL

Space Shuttle Upgrades E. Henderson, *NASA Johnson*, Houston, TX	**Boeing Liquid FlyBack Booster (LFBB)** I. Victer, *Boeing Co.*, Downey, CA	**Lockheed Martin Liquid Flyback Booster** T. Mobley, *Lockheed Martin Michoud Space Systems*, New Orleans, LA	**5th Segment Solid Rocket Booster** G. Smith, *Thiokol*, Brigham City, UT	**Channel Wall Nozzel** R. Kuck, *Rocketdyne*, Canoga, CA	**Non-Toxic Orbital Maneuvering System/Reaction Control System** E. Herbert, *NASA Johnson*, Houston, TX	**AIAA-3.7 Pres.** **Proton Exchange Membrane Fuel Cell** K. Bradley, *NASA Johnson*, Houston, TX	

Session 4 Status of Selected Space Programs
S. SAUCIER, NASA Marshall, Huntsville, AL

Space Based Laser Demonstrator M. Moore, *Space–Based Laser Program Ofc.*, Redondo, CA	**Mars Sample Missions Overview** S. Saunders, *NASA Jet Propulsion Lab*, Pasadena, CA	**AIAA-98-5118** **Human Mars Mission: Transportation Assessment** L. Kos, *NASA Marshall*, Huntsville, AL	**Status of the AX AF Mission** F. Wojatalik and M. Weisskopf, *NASA Marshall*, Huntsville, AL	**Status of the Teledesic System** D. Williams, *Teledesic LLC*, Kirkland, WA	**Human Mars Mission: Cost Driven Architecture Assessments** B. Donahue, *Boeing Space Systems*, Huntsville, AL		

Session 5 Interagency Technology Collaborations for Earth and Space Science I
G. VARSI, NASA Headquarters, Washington, DC

1:30 p.m.
Speakers TBD Based on Abstracts Submitted in August for Competition for Best Paper on Interagency Technology Collaboration for Earth and Space Science.